it is warmer in the anticyclone than in the low. This holds for Europe but is not entirely confirmed for the United States. The height of the base of the stratosphere varies in Europe with cyclonic and anticyclonic weather from about 8 to 13 kms. It also varies with latitude, averaging 9.6 at Petrograd; 10.6 in England; 11 in Italy; and 11.7 in Canada.

Thus it can readily be predicted that at a height of 10 kms. in the latitude of New York an airman rising on an afternoon in the early fall will experience a temperature lapse or vertical decrease amounting in all to 200 kilograds, *i. e.*, from 1,050 to 850 kilograds, using a scale on which the absence of all molecular heat is represented by 0 and the ordinary freezing point by 1,000. On the Centigrade scale this would be from 14° above freezing to 41 degrees below freezing.

If our atmosphere were homogeneous, we should reach its top at a height of 8,000 meters. There would then be no need of superchargers; and oxygen tanks would be advantageous but not absolutely indispensable. But this does not occur in nature and the density of our aerial envelope at 8,000 meters is actually 40 per cent. of what it is at the surface. At 10,000 meters it is just 33 per cent. of the surface density.

Km.	Kk.	Kb.	gm/m^3.
20	783	55	87
19	787	63	102
18	783	74	121
17	772	87	144
16	772	102	169
15	772	120	198
14	776	142	233
13	783	167	268
12	790	195	314
11	802	228	365
10	816	266	415
9	838	309	470
8	864	358	528
7	890	413	592
6	920	475	662
5	945	543	733
4	967	618	815
3	989	703	905
2	1,008	798	1,011
1	1,018	903	1,134
0	1,033	1,017	1,258

The preceding table somewhat modified from the data given by Dines in his recent paper on the "Characteristics of the Free Atmosphere" indicates the average temperature, pressure, and density of the air at various heights. The height is in kilometers, temperature in kilograds, pressure in kilobars and density in grams per cubic meter.

Schroeder's thermograph indicated a minimum temperature of —55 degrees C. (or 99 degrees below freezing on the Fahrenheit scale). This on the new temperature scale is 799. It will be seen that this temperature indicates a height of about 11,000 meters.

In one of Rohlf's ascents he went beyond the top of the troposphere or above what might be called the temperature lid. On that date, the base of the stratosphere was below 10 kilometers and, therefore, he passed into a somewhat warmer level even though at a greater elevation.

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THE SEPARATION OF THE ELEMENT CHLORINE INTO CHLORINE AND META-CHLORINE

ALTHOUGH many attempts have been made to separate an element into two or more different atomic species, in no case have the experiments met with success. In my opinion this has been due largely to the fact that in all cases where it is *known* that isotopes exist, as in the element lead, the conditions imposed upon the experiments by the relative atomic weights of the different atomic species are such as to be extremely difficult to meet. For this reason, when five years ago I decided to make a separation of an element into isotopes, it seemed that it would be easier to separate the isotopes in an element where isotopes were not known to exist, than to meet the extremely arduous conditions of the known cases.

In 1915 I gave conclusive evidence that chlorine, magnesium, and silicon (in addition to neon as discovered by Thomson), among the light elements, are mixtures of isotopes, and that the atomic weight of the lighter isotope is 35.0 for chlorine, 24.0 for mag-

nesium, and 28.0 for silicon. Among the heavier elements there are probably few elements which are not mixtures of isotopes. Thus there is excellent evidence in the atomic weights that the following elements are mixtures: nickel, copper, zinc, and practically all of the other elements form atomic number 28 to atomic number 80. The radio-elements from thallium (No. 81) to uranium (92) were at that time known to be mixtures of isotopes.

Experiments on the diffusion of chlorine gas were begun by Dr. W. D. Turner and myself in 1916, and early in 1917 slight differences in density were detected, but the chlorine was not entirely pure. Chlorine was used because it could be obtained in cylinders, and its flow was therefore very easy to control. However if chlorine consists of two isotopes, chlorine (Cl) and meta-chlorine (*Cl*), there are three forms of molecular chlorine: Cl-Cl, Cl-*Cl*, and *Cl*-*Cl*, and this is unfavorable to the diffusion. For this reason we have carried out most of our work by the use of hydrogen chloride gas, which, while unfortunately not obtainable in this country compressed in cylinders, at least has the advantage that its molecules contain only one atom of chlorine each, and that the hydrogen of the molecule has little effect in increasing the molecular weight.

This work was interrupted by the war, but by the summer of 1919 about ten thousand liters of gas had been diffused, a part of this diffusion being done by T. H. Liggett. In October, 1919, I interested Mr. C. E. Broeker in this problem. He has diffused about eight thousand liters of this gas and we hope soon to have an enlarged apparatus capable of diffusing a thousand liters per day, in the first section. At present we have five large units in operation or ready for operation.

The separation by diffusion of gases whose molecular weights lie close together is, according to the diffusion theory of Lord Rayleigh, an extremely slow process. Up to the present time we have concentrated our efforts upon the diffusion itself, and have spent little time in analytical work. The preliminary analyses indicate that the density of the fraction which remains inside the diffusion tubes, is increasing at about the rate predicted by the Rayleigh theory of diffusion, if we consider 35.0 as the atomic weight of chlorine, and 37.0 as the atomic weight of meta-chlorine. We have tested for most of the impurities which might be present except arsenic trichloride. The hydrogen chloride gas is generated from C. P. hydrochloric acid by the action of C. P. sulphuric acid. The next step in our work of proving that a separation has been effected is to secure larger quantities of diffused material, since our final fractions are still small, so that we may be more certain of our purification of the material, and then to make precise atomic weight determinations. If on such further purification we obtain an atomic weight for the heavy fraction as high as that already obtained in our preliminary analyses, we will have definite evidence that we have separated chlorine into a heavier and a lighter isotope. This will be of importance in two ways, first, it will be the *first experimental separation of an element into parts,* and second, it will be one of the strongest links in the proof that *the nucleus of the hydrogen atom is actually the positive electron.*

As stated above, I gave in a series of papers published five years ago[1] a system of atomic structure which gave very strong indications that chlorine, magnesium, silicon, and the other elements specified, are mixtures of isotopes. In fact this system of structure, for which there was much evidence, depended for its validity upon the existence of these isotopes, and in 1916 I published a preliminary notice[2] stating that we were working, on the separation of chlorine into isotopes. It is of great interest that Aston in a preliminary note written to *Nature* in December, 1919, states that his results obtained by positive rays indicate that both chlorine and mercury are mixtures of isotopes, with atomic

[1] *Journal of the American Chemical Society,* 37, 1367–96, especially pages 1390, 1391, 1387.

[2] *Ibid.,* 38, p. 19.

weights 35 and 37 for chlorine, thus confirming to this extent my theory with respect to the light elements and also for the heavy elements. Also in accord with the theory presented in my papers on atomic weights, he finds that the atomic weights on the oxygen basis are practically whole numbers.

The details of our experimental work on the separation of chlorine will be published as soon as we have collected enough material to enable us to make a more careful purification of our material, and when in addition the accurate atomic weight determinations have been completed. We expect to make the final separations by thermal diffusion. The theory of this method has been worked out by Chapman. Mr. Broeker and I are also beginning preparations for an extensive attempt to separate hydrogen into hydrogen and meta-hydrogen, the latter with an atomic weight of 3.0. While there was sufficient evidence for the existence of a meta-chlorine in ordinary chlorine to be found already in the atomic weights, there is no such evidence that ordinary hydrogen contains meta-hydrogen. However, there is evidence that the meta-hydrogen nucleus of a formula $h_3e_2^+$, where h is the hydrogen nucleus and e is the negative electron, is the most important unit in the building of atomic nuclei, with the exception of the alpha particle ($h_4e_2^{++}$). The nucleus of an isotopic atom of higher atomic weight differs from the nucleus of the normal atom by the presence of a mu group (h_2e_2) which carries no *net* charge, and which, if it were alone, would have an atomic number zero. Isotopes of higher atomic weight are also formed by the addition of alpha groups ($h_4e_2^{++}$), each alpha group being attached by two cementing electrons. This is equivalent to the addition of an h_4e_4 group. The details of this system will be found in a paper now in print in the *Physical Review*.

It should have been noted in the above paper that neon, magnesium, and silicon, the even numbered light elements which contain isotopes, lie *adjacent* in the even numbered series, since their numbers are 10, 12, and 14. It is *possible* that a third isotope of chlorine exists.

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February 28, 1920

WILHELM PFEFFER

WILHELM PFEFFER, with Sachs the founder of plant-physiology as it has been studied for more than a generation, died in Leipzig on January 31, of this year. A long line of Americans, as well as many other foreigners, resorted to him, in addition to the Germans who studied with him. He probably shared with Strasburger the distinction of having a larger number of foreign students of botany than any other German university professor. By these men, and many others, he will be remembered as a striking personality as well as a great leader in the science to which he devoted his life.

The details of his life are probably known to few Americans, but the general outlines may well be set down. He was born March 9, 1845, in Grebenstein near Cassel, the son of an apothecary. The elements of science, and scientific curiosity, he probably acquired from his father; for the old-time German Apotheker was a very different sort of person from the American drug-store proprietor of to-day. He studied at the universities in Göttingen, Marburg, Berlin and Würzburg, taking his doctor's degree at Göttingen in 1865. He began his teaching career as Privatdocent in Marburg, going thence as Ausserordentlicher to Bonn and as Ordentlicher Professor to Basel, Switzerland. In 1878 he removed to Tübingen where, I believe, the first Americans worked with him, Goodale of Harvard, Wilson of Philadelphia, Campbell of Stanford, and perhaps others. In 1887 he went to Leipzig, where he stayed for the rest of his life, in spite of calls to what, to others, might have seemed more attractive posts. But in the Botanisches Institut in Leipzig he had a laboratory fitted to his ideas and desires, with a garden adjacent in which the material which he and his associates used could be readily grown, a garden of such size, position, and plan that it took the